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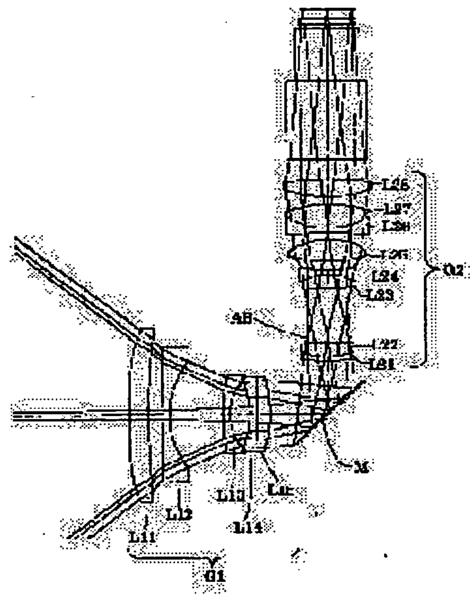
(54) PROJECTION LENS SYSTEM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a projection lens system by which long back focus, a large off-axis light quantity and telecentricity are secured even in spite of a wide viewing angle and also short distance projection and also the various kinds of aberration including distortion aberration are reduced.

SOLUTION: This projection lens system is provided with the first lens group G1 of negative refracting power and the second lens group G2 of positive refracting power in order from an enlarging side. A first lens L11 arranged on a most enlarging side possesses an aspherical surface in the first lens group. When the back focus at the time of air conversion is set as Bf, the focal distance of an entire lens system is set as (f), the air conversion rate of an interval between the first lens group and the second lens group is set as D12 and the focal distance of the first lens group is set as f1, the conditions of 4.0<Bf/f, 3.0<D12/f<5.0 and 1.0<|f1/f|<3.0 are satisfied.



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CLAIMS

[Claim(s)]

[Claim 1] Have the 2nd lens group which has forward refractive power toward a contraction side with the 1st lens group which has negative refractive power in order from an expansion side, and it sets in said 1st lens group. The 1st lens arranged most at the expansion side has the aspheric surface, and sets the back focus at the time of air conversion to Bf. When the focal distance of the whole lens system is set to f, the air reduced property of spacing of said 1st lens group and said 2nd lens group is set to D12 and the focal distance of said 1st lens group is set to f1, The projection lens system characterized by satisfying the conditions of $4.0<Bf/f3.0<D12/f<5.01.0<|f1/f|<3.0$.

[Claim 2] The projection lens system according to claim 1 characterized by establishing the optical-path modification means for changing the optical path of the flux of light from said 1st lens group to said 2nd lens group into the optical path between said 1st lens groups and said 2nd lens groups.

[Claim 3] decreasing air spacing of said 1st lens group and said 2nd lens group, moving the whole lens system to an expansion side, when conjugation length is set constant -- a projection scale factor -- high twice -- the low twice from a side -- the projection lens system according to claim 1 or 2 characterized by making it change to a side.

[Claim 4] A projection lens system given in claim 1 characterized by moving a part or all of said 1st lens group, and performing focusing while moving the whole lens system when changing projection distance and changing a projection scale factor thru/or any 1 term of 3.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is the projection lens system which has the good tele cent rucksack engine performance as a projection lens system which carries out expansion projection to the color composition prism by the side of a space light modulation element on a screen in the finite distance which had the image displayed on display devices, such as a space light modulation element, fixed, and has the color property which was further excellent in low distortion, and relates to the suitable projection lens system for thin-shape-izing and a miniaturization of a projection display

especially, concerning a projection lens system.
[0002]
[Description of the Prior Art] In recent years, the projection display has spread widely. The so-called tooth-back projection type which displays by projecting image light from the tooth-back side to the screen of a transparency mold as one of such the projection displays of projection display is known. The flux of light which collimated the light of the source of the white light by the reflector etc. is decomposed into the flux of light of three colors of red, green, and blue by the color-separation mirror by the projection display of this kind of tooth-back projection mold, for example. And ON light of the flux of light of these 3 color is carried out to each space light modulation element formed according to red, green, and a blue image electrical signal. Color composition is carried out in color composition optical system at white, and expansion projection of the **** obtained in tops, such as each space light modulation element corresponding to these red, green, and blue, is carried out on the screen of a transparency mold through a projector lens.
[0003] In addition, in consideration of the limit by the quick return mirror etc., many photographic lenses of the wide angle system for single-lens reflex cameras with a long back focus and wide angle projector lenses for projection TV by CRT are also proposed as a lens of the same configuration. Moreover, in the lens system which forms a projector lens, the structure of changing 90 degrees of optical paths may be taken as a projection display. Thereby, it becomes possible to change the orientation of the case of the projection device in a projection display, and the installation direction of the various optical elements from the color separation inside a projection device to color composition. Furthermore, it becomes possible to miniaturize the various above-mentioned optical elements, and it becomes possible to attain the miniaturization of a projection display.
[0004]
[Problem(s) to be Solved by the Invention] With the configuration of the above projection displays, optical elements, such as a dichroic prism or a dichroic mirror, may be arranged as color composition optical system. Moreover, on the occasion of using a reflective type space light modulation element etc., optical elements, such as polarization beam splitter prism or a polarization beam splitter mirror, may be arranged. In such a case, the so-called back focus equivalent to the distance from a space light modulation element etc. to the last edge of a projector lens must be secured for a long time.
[0005] Moreover, as a projection indicating equipment, when forming an expansion image in the whole screen of a transparency mold, it is necessary to shorten projector distance for the miniaturization of the projection indicating equipment itself. For that purpose, it is necessary to wide-angle-ize a projector lens, to enlarge the angle of divergence of the outgoing radiation light by the side of expansion, and to obtain a big screen. Moreover, in order to lessen color nonuniformity on the screen with which it is projected on image light, as the polarization beam splitter prism used in case a reflective type space light modulation element etc. is used, or a polarization beam splitter mirror, the beam-of-light include-angle width of face which hits these coat sides covers the whole region including the dichroic prism and dichroic mirror which are used for color composition optical system. - It is better to be a law. Therefore, it is necessary to have tele cent rucksack nature so that the chief ray besides the shaft of a projector lens may become perpendicular to a space light modulation element etc.
[0006] Moreover, although display devices, such as LCD, are usually adopted as a space light modulation element, since LCD is driven using a matrix electrode, it is difficult [it] to amend distortion of a projection image electrically. If it carries out from such a situation, the thing small as much as possible of the distortion aberration of a projector lens is desirable. However, this serves as a failure to obtaining wide-angle-izing and the long back focus of a projector lens. That is, as a projector lens, after securing removal of distortion aberration, wide-angle-izing, and a long back focus, if tele cent rucksack nature is given, it turns out that it has the inclination for a lens overall length to become long or for the diameter of a lens etc. to become large. Moreover, the photographic lens of the wide angle system for single-lens reflex cameras and the projector lens of a back focus for projection TV by CRT are inadequate, and

since the incident angle and the angle of emergence of an axial outdoor daylight bundle are tight, the present condition is that there is no tele cent rucksack nature and the quantity of light has also decreased.

[0007] Furthermore, in recent years, although the lens of high resolving is called for corresponding to highly-minute-izing of a space light modulation element etc., a color gap of the pixel by the chromatic aberration of magnification in a screen periphery is becoming a problem with a raise in resolving of a lens. Moreover, the expansion image of a request on a screen may be obtained neither according to a projection lens nor the manufacture error of projection equipment, a projection lens needs to adjust a projection scale factor, and it is necessary to adjust to a desired projection scale factor in a projection indicating equipment.

[0008] Furthermore, in a projection display, even if it is the case with which screen sizes differ, the same projector lens can be used by adjusting the projector distance of a projector lens and a screen. Since aberration occurs by the very small difference in each beam-of-light include angle which condenses on a screen at this time, it is necessary to adjust so that this aberration may become as small as possible.

[0009] Moreover, it becomes possible by establishing an optical-path modification means in a projection lens to change the orientation of the case of the projection device in a display, and the installation direction of the various optical elements from the color separation inside a projection device to color composition as a projection display. Furthermore, it becomes possible to miniaturize the various above-mentioned optical elements, and it becomes possible to attain the miniaturization of a projection display.

[0010] This invention is made in view of the above-mentioned technical problem, after adopting the technique made more advantageous than a whole delivery method as a projection lens system in which a focus is possible, even if it is an extensive field angle and is short distance projection, it secures a long back focus, the big amount of axial outdoor daylight, and tele cent rucksack nature, and it aims at offering the small projection lens system of many aberration which moreover includes distortion aberration. Moreover, it aims at offering the projection lens system which can adjust change of the projection scale factor by the manufacture error to a desired scale factor.

[0011]

[Means for Solving the Problem] In order to solve said technical problem, in this invention, have the 2nd lens group which has forward refractive power toward a contraction side with the 1st lens group which has negative refractive power in order from an expansion side, and it sets in said 1st lens group. The 1st lens arranged most at the expansion side has the aspheric surface, and sets the back focus at the time of air conversion to Bf. When the focal distance of the whole lens system is set to f, the air reduced property of spacing of said 1st lens group and said 2nd lens group is set to D12 and the focal distance of said 1st lens group is set to f1, The projection lens system characterized by satisfying the conditions of 4.0<Bf/f3.0<D12/f<5.01.0<|f1/f|<3.0 is offered.

[0012] According to the desirable mode of this invention, into the optical path between said 1st lens groups and said 2nd lens groups, the optical-path modification means for changing the optical path of the flux of light from said 1st lens group to said 2nd lens group is established. moreover, the thing for which air spacing of said 1st lens group and said 2nd lens group is decreased, moving the whole lens system to an expansion side when conjugation length is set constant -- a projection scale factor -- high twice -- the low twice from a side -- it is desirable to make it change to a side. Furthermore, when changing projection distance and changing a projection scale factor, while moving the whole lens system, it is desirable to move a part or all of said 1st lens group, and to perform focusing.

[0013]

[Embodiment of the Invention] As mentioned above, in the projection lens system of this invention, it is considering as 2 group configurations of the 1st lens group of negative refractive power, and the 2nd lens group of forward refractive power from the screen side (expansion side) at order. And it is possible to realize the small projection lens system of many aberration which is extensive field angles, and

secures a long back focus, the big amount of axial outdoor daylight, and tele cent rucksack nature even if it is short distance projection, and moreover includes distortion aberration after adopting the focusing technique made more advantageous than a whole delivery method by introducing the aspheric surface into the 1st lens most arranged in the 1st lens group at the screen side. Furthermore, it is possible to realize the projection lens system which can adjust change of the projection scale factor by the manufacture error to a desired scale factor.

[0014] Moreover, in the projection lens system of this invention, it becomes possible by establishing the optical-path modification means for changing the optical path of the flux of light from the 1st lens group to the 2nd lens group into the optical path between the 1st lens group and the 2nd lens group to change the orientation of the case of the projection device in a projection display, and the installation direction of the various optical elements from the color separation inside a projection device to color composition. Furthermore, it becomes possible to miniaturize various optical elements, and it becomes possible to attain the miniaturization of a projection display.

[0015] In the projection lens system of this invention, when changing projection distance and changing a projection scale factor, while moving the whole lens system, a part or all of the 1st lens group can be moved, and focusing (focus) can be performed. furthermore, the thing for which air spacing of the 1st lens group and the 2nd lens group is decreased, moving the whole lens system to a screen side (expansion side) when conjugation length is set constant — a projection scale factor — high twice — the low twice from a side — it can be made to change to a side

[0016] It is satisfied with the projection lens system of this invention of following conditional-expression (1) - (3). Conditional expression (1) In - (3), Bf is a back focus at the time of air conversion, f is the focal distance of the whole lens system, D12 is the air reduced property of spacing of the 1st lens group and the 2nd lens group, and f1 is the focal distance of the 1st lens group.

[0017] $4.0<Bf/f$ (1)

$3.0<D12/f<5.0$ (2

$1.0<|f1/f|<3.0$ (3)

[0018] Conditional expression (1) is the conditional expression for shortening the focal distance of a projection lens system while securing sufficient back focus, and it has specified the suitable range about the ratio with the focal distance f of the back focus Bf at the time of air conversion, and the whole lens system. If it deviates from the range of conditional expression (1), since it will become difficult to insert color composition prism, etc. polarization beam splitter prism, etc. into the optical path between a projection lens system, a space light modulation element, etc., it is inconvenient.

[0019] Conditional expression (2) is the conditional expression for keeping good air spacing in alignment with the optical axis of the 1st lens group and the 2nd lens group, and has specified the suitable range about the ratio of the air reduced property D12 of spacing of the 1st lens group and the 2nd lens group, and the focal distance f of the whole lens system. If it exceeds the upper limit of conditional expression (2), sufficient air spacing to establish an optical-path modification means is securable, but since a lens overall length becomes large too much, it is inconvenient. On the other hand, since it becomes impossible to secure air spacing required to establish an optical-path modification means when less than the lower limit of conditional expression (2), it is inconvenient.

[0020] Conditional expression (3) is the conditional expression for keeping good a back focus and optical-character ability while stopping the magnitude of the lens whole system good, and it has specified the suitable range about the ratio of the focal distance f1 of the 1st lens group, and the focal distance f of the whole lens system. Since the configuration of a retro focus mold will become weak, and it becomes difficult to keep a back focus long, it is [be / it / if / it exceeds the upper limit of conditional expression (3),] inconvenient. Moreover, if less than the lower limit of conditional expression (3), a long back focus can be obtained, but since generating of astigmatism or distortion aberration increases and the amendment becomes difficult, it is inconvenient.

[0021] Although the so-called retro focus type of 2 group configurations which become order like the

projection lens system of this invention from the 1st lens group of negative refractive power and the 2nd lens group of forward refractive power from a screen side was advantageous to reservation and wide-angle-izing of a long back focus and it was suitable as a projection lens system used for a projection display, generating of negative distortion aberration was large and the amendment was the big technical problem were difficult. Then, in the projection lens system of this invention, it is possible to amend negative distortion aberration good by introducing the aspheric surface from a screen side in the 1st lens group of 2 group configurations which become order from the 1st lens group of negative refractive power, and the 2nd lens group of forward refractive power.
[0022] It is higher for the amendment effectiveness of distortion aberration to introduce the aspheric surface into the lens near a screen side especially. Moreover, as compared with the diameter of a lens in the former which arranges the lens group of forward refractive power and amends distortion aberration to the screen side of the 1st lens group of negative refractive power, it becomes possible to make magnitude of the direction of a path of a lens small, and the miniaturization of a lens system can be attained. The example which introduced the aspheric surface into the field by the side of the screen of the 1st lens of the 1st lens group arranged most at the screen side as a high example of the amendment effectiveness of distortion aberration also in each example of this invention is shown so that it may mention later.
[0023] Moreover, generally in the projection display, the physical relationship of a screen, a space light modulation element, etc. is being fixed, and it is difficult to change the distance of the direction of an optical axis to acquiring the projection image of a desired magnifying power on a screen structural. So, in this invention, when the projection image of the magnifying power of a request on a screen is acquired neither according to a projection lens system nor the manufacture error of a projection display, conjugation length is set constant. That is, by changing air spacing of the 1st lens group of negative refractive power, and the 2nd lens group of forward refractive power, moving the whole lens system to an expansion side (screen side) keeping constant the distance of a screen, a space light modulation element, etc. It is possible to obtain a desired magnifying power, where optical-character ability is kept good. In all the examples of this invention, above-mentioned variable power is possible so that it may mention later.
[0024] Furthermore, in a projection display, even if it is the case with which screen sizes generally differ, the same projection lens system can be used by adjusting the projector distance of a projection lens system and a screen. Since aberration occurs by the very small difference in each beam-of-light include angle which condenses on a screen at this time, it is necessary to adjust so that this aberration may become as small as possible. In this invention, when changing projection distance and changing magnifying power, while moving the whole lens system, magnifying power can be changed by moving a part or all of the 1st lens group of negative refractive power, and performing focusing, keeping optical-character ability good.
[0025] In the 1st example and the 2nd example of this invention, while moving the whole lens system in accordance with an optical axis, air spacing of the 1st lens of the 1st lens group of negative refractive power and the 2nd lens and air spacing of the 1st lens group of negative refractive power and the 2nd lens group of forward refractive power are changed, and focusing is performed, so that it may mention later. On the other hand, in the 3rd example, while moving the whole lens system in accordance with an optical axis, spacing of the 1st lens of the 1st lens group of negative refractive power and the 2nd lens is changed, and focusing is performed.
[0026] Moreover, it becomes possible by generally establishing an optical-path modification means in a projection lens system to change the orientation of the case of the projection device in a display, and the installation direction of the various optical elements from the color separation inside a projection device to color composition as a projection display. Furthermore, it becomes possible to miniaturize the various above-mentioned optical elements, and it becomes possible to attain the miniaturization of a projection display. Also in this invention, it is possible by establishing an optical-path modification means

between the 1st lens group of negative refractive power, and the 2nd lens group of forward refractive power to change the orientation of the case of the projection device in a display, and the installation direction of the various optical elements from the color separation inside a projection device to color composition as a projection display. Furthermore, it becomes possible to miniaturize the various above-mentioned optical elements, and it is possible to attain the miniaturization of a projection display.

[0027] In the 1st example of this invention, a mirror (plane mirror) is adopted as an optical-path modification means, and the structure of changing 90 degrees of optical paths is shown so that it may mention later. Since a medium serves as air, while in the case of the optical-path modification means by the mirror an optical path becomes short and being able to shorten a lens overall length as compared with the case of the optical-path modification means by prism, it becomes possible to avoid loss of the quantity of light by the internal absorption of prism. Moreover, as a mirror, it is possible to use a metal mirror. Furthermore, when using any of a P wave or an S wave they are in a projection lens system, it is possible to use the mirror which used the dielectric film which reflects a P wave or an S wave. On the other hand, in the 2nd example, prism is adopted as an optical-path modification means, and the structure of changing 120 degrees of optical paths is shown. In the case of the optical-path modification means by prism, as compared with the case of the optical-path modification means by the mirror, since a medium serves as glass (optical material), it becomes possible to lengthen an optical path and it becomes possible to enlarge an optical-path modification angle. In addition, the 3rd example shows the structure which does not adopt an optical-path modification means.

[0028]

[Example] Hereafter, the example of this invention is explained based on an accompanying drawing. In each example, the projection lens system of this invention consists of a 1st lens group G1 which has negative refractive power, and a 2nd lens group G2 which has forward refractive power sequentially from the screen side (expansion side). And in the 1st lens group G1, the field by the side of the screen of the 1st lens L11 arranged most at the screen side is formed in the shape of the aspheric surface.

[0029] Moreover, in each example, when the aspheric surface set the height of a direction perpendicular to an optical axis to y, and sets distance (the amount of sags) in alignment with the optical axis from the tangential plane in the top-most vertices of the aspheric surface to the location on the aspheric surface in height y to z, top-most-vertices radius of curvature is set to r, a constant of the cone is set to kappa and the n-th aspheric surface multiplier is set to Cn, it is expressed with the following formulas (a).

[0030]

[Equation 1] 1+(1-kappa-y 2 / r2) 1 / z= (y2/r) / {2}+C4, y4+C6 and y6+C8, y8 (a)

In each example, * mark is given to the right-hand side of a field number in the lens side formed in the shape of the aspheric surface.

[0031] The [1st example] Drawing 1 is drawing showing the lens configuration of the projection lens system concerning the 1st example of this invention. In the projection lens system of the 1st example the 1st lens group G1 The negative meniscus lens L11 which turned the aspheric surface-like convex to the screen side sequentially from the screen side, A biconcave lens L12 and the negative meniscus lens L13 which turned the convex to the screen side, It consists of cemented lenses (L14, L15) which consist of lamination of the negative meniscus lens L14 which turned the concave surface to the screen side, and the positive meniscus lens L15 which turned the concave surface to the screen side.

[0032] The cemented lens with which the 2nd lens group G2 consists of lamination of the negative meniscus lens L21 which turned the convex to the screen side, and the biconvex lens L22 to which the convex of curvature strong against a screen side was turned sequentially from a screen side (L21, L22), The cemented lens which consists of lamination of aperture-diaphragm AS, the biconvex lens L23 which turned the convex of weak curvature to the screen side, and the biconcave lens L24 to which the concave surface of curvature strong against a screen side was turned (L23, L24), The cemented lens which consists of lamination of the biconvex lens L25 which turned the convex of weak curvature to the screen side, the biconcave lens L26 which turned the concave surface of weak curvature to the screen

side, and the biconvex lens L27 to which the convex of curvature strong against a screen side was turned (L26, L27), It consists of biconvex lenses L28 to which the convex of curvature strong against a screen side was turned.

[0033] In addition, in the 1st example, into the optical path between the 1st lens group G1 and the 2nd lens group G2, the mirror (plane mirror) M as an optical-path modification means has been arranged, and 90 degrees of optical paths are changed. Moreover, two or more prism as color composition optical system is arranged at the contraction side of the 2nd lens group G2, i.e., the inside of the optical path between the 2nd lens group G2 and a space light modulation element. Furthermore, while moving the whole lens system in accordance with an optical axis, air spacing (d2) of the 1st lens L11 of the 1st lens group G1 and the 2nd lens L12 and air spacing (d9) of the 1st lens group G1 and the 2nd lens group G2 are changed, and focusing is performed. Moreover, variable power is performed by changing air spacing (d9) of the 1st lens group G1 and the 2nd lens group G2, moving the whole lens system to a screen side.

[0034] The value of the item of the projection lens system concerning the 1st example of this invention is hung up over the next table (1). the whole table (1) item — setting — f — the focal distance of a projection lens system — omega expresses a half-field angle and, as for Bf, FNO expresses the back focus at the time of air conversion for the f number, respectively. In the lens item of a table (1) the 1st column moreover, the number of the field from a screen side r of the 2nd column the radius of curvature (the case of the aspheric surface top-most-vertices radius of curvature) of each field In the refractive index to e line (lambda= 546.07nm) whose n of the 4th column of d of the 3rd column is criteria wavelength about spacing to the next field of each field, nu of the 5th column shows the Abbe number, respectively, and the refractive index 1.0 of air is omitted. Also in subsequent tables (2) and (3), the above-mentioned notation is the same.

[0035]

[Table 1]

(Whole item)

f=12.53FNO=2.93omega=40.09Bf=52.35 (lens item)

Field number r d n nu 1* 5000.000 8.00 1.49290 57.1 (L11)

2 331.058 (D2= Adjustable) 3 -1543.299 3.00 1.61520 58.7 (L12)

4 42.178 22.50 5 94.147 3.00 1.61520 58.7 (L13)

6 25.843 8.00 7 -44.983 3.00 1.80811 46.5 (L14)

8 -380.525 6.00 1.76167 27.5 (L15)

9 -51.938 (D9= Adjustable) 10 73.183 2.00 1.77621 49.6 (L21)

11 27.256 6.00 1.72538 34.7 (L22)

12 -267.261 2.90 13 Infinity 21.80 (Aperture-Diaphragm AS)

14 86.512 6.50 1.49845 81.6 (L23)

15 -20.994 2.00 1.80811 46.5 (L24)

16 56.494 4.00 17 60.747 10.00 1.48915 70.2 (L25)

18 -28.021 2.90 19 -227.657 2.00 1.77621 49.6 (L26)

20 31.799 10.50 1.49845 81.6 (L27)

21 -54.947 3.40 22 46.651 8.00 1.48915 70.2 (L28)

23 -133.128 (D23= Adjustable) 24 Infinity 35.50 1.51872 64.1 25 Infinity 23.00 1.84668 24.0 26 Infinity 1.66 27 Infinity 2.70 1.51872 64.1 28 Infinity (Aspheric Surface Multiplier)

1 page kappa=1.0000C4=2.7105x10-6C6=-7.4595x10-10C 8= 2.0675x10-13 (spacing at the time of variable power)

Reference value Projection scale factor 73.21 71.89 70.57 d2 6.00 6.00 6.00 d9 50.33 48.00 45.76 d23 8.84 9.44 10.05 (spacing at the time of focusing) Reference value Projection scale factor 48.17 71.89 83.75 d2 6.40 6.00 5.90 d9 47.10 48.00 48.80 d23 9.779.44 9.21 (value corresponding to conditional expression)

(1) Bf/f=4.18(2) D12/f=3.83(3) |f1/f|=1.95[0036] Drawing 2 - drawing 6 are many aberration Figs. of the

1st example. namely, many one [71.89 times the projection scale factor of this] o'clock aberration Figs. whose drawing 2 is the projection scale factors of criteria — drawing 3 — many one [48.17 times the projection scale factor of this] o'clock aberration Figs. — in drawing 4 , drawing 5 shows many one [73.21 times the projection scale factor of this] o'clock aberration Figs., and drawing 6 shows many one [70.57 times the projection scale factor of this] o'clock aberration Figs. for many one [83.75 times the projection scale factor of this] o'clock aberration Figs., respectively.

[0037] each aberration Fig. — setting — NA — the numerical aperture by the side of a space light modulation element — Y — the image quantity of a space light modulation element — in e, C shows C line (lambda= 656.28nm), and F shows the F line (lambda= 486.13nm) for e line (lambda= 546.07nm), respectively. Moreover, in the aberration Fig. which shows astigmatism, a continuous line shows the sagittal image surface and the broken line shows the meridional image surface. Also in subsequent aberration drawing 8 -12 and aberration drawing 14 -18, the above-mentioned notation is the same. In the 1st example, it turns out that many aberration is amended good in the condition of a reference value, the condition which performed variable power, and the condition of having performed focusing so that clearly from each aberration Fig.

[0038] The [2nd example] Drawing 7 is drawing showing the lens configuration of the projection lens system concerning the 2nd example of this invention. In the projection lens system of the 2nd example the 1st lens group G1 The negative meniscus lens L11 which turned the aspheric surface-like convex to the screen side sequentially from the screen side, The negative meniscus lens L12 which turned the convex to the screen side, and the negative meniscus lens L13 which turned the convex to the screen side, It consists of cemented lenses (L14, L15) which consist of lamination of a biconcave lens L14 and the positive meniscus lens L15 which turned the convex to the screen side.

[0039] The cemented lens with which the 2nd lens group G2 consists of lamination of the negative meniscus lens L21 which turned the convex to the screen side, and the biconvex lens L22 to which the convex of curvature strong against a screen side was turned sequentially from a screen side (L21, L22), The cemented lens which consists of lamination of aperture-diaphragm AS, the biconvex lens L23 which turned the convex of weak curvature to the screen side, and the biconcave lens L24 to which the concave surface of curvature strong against a screen side was turned (L23, L24), The cemented lens which consists of lamination of the biconvex lens L25 which turned the convex of weak curvature to the screen side, the biconcave lens L26 which turned the concave surface of weak curvature to the screen side, and the biconvex lens L27 to which the convex of curvature strong against a screen side was turned (L26, L27), It consists of biconvex lenses L28 to which the convex of curvature strong against a screen side was turned.

[0040] In addition, in the 2nd example, into the optical path between the 1st lens group G1 and the 2nd lens group G2, the prism P as an optical-path modification means has been arranged, and 120 degrees of optical paths are changed. Moreover, two or more prism as color composition optical system is arranged like the 1st example at the contraction side of the 2nd lens group G2, i.e., the inside of the optical path between the 2nd lens group G2 and a space light modulation element. Furthermore, like the 1st example, while moving the whole lens system in accordance with an optical axis, air spacing (d2) of the 1st lens L11 of the 1st lens group G1 and the 2nd lens L12 and air spacing (d9) of the 1st lens group G1 and the 2nd lens group G2 are changed, and focusing is performed. Moreover, variable power is performed like the 1st example by changing air spacing (d9) of the 1st lens group G1 and the 2nd lens group G2, moving the whole lens system to a screen side. The value of the item of the projection lens system concerning the 2nd example of this invention is hung up over the next table (2).

[0041]

[Table 2]

(Whole item)

f=12.38FNO=2.91omega=40.97Bf=54.31 (lens item)

Field number r d n nu 1* -5193.789 9.00 1.49290 57.1 (L11)

2 121.677 (D2= Adjustable) 3 807.816 3.00 1.65141 53.0 (L12)
4 74.148 17.50 5 61.357 3.00 1.61520 58.7 (L13)
6 24.608 9.20 7 −170.584 3.00 1.77621 49.6 (L14)
8 25.717 10.00 1.72733 29.2 (L15)
9 224.817 (D9= Adjustable) 10 Infinity 50.50 1.51872 64.1 (P)
11 Infinity 4.00 12 45.790 2.00 1.77621 49.6 (L21)
13 17.611 5.00 1.59667 35.3 (L22)
14 −430.954 2.90 15 Infinity 20.30 (Aperture-Diaphragm AS)
16 105.725 5.50 1.48915 70.2 (L23)
17 −49.089 2.00 1.80811 46.5 (L24)
18 54.686 4.00 19 58.982 10.00 1.49845 81.6 (L25)
20 −31.590 2.90 21 −607.242 2.00 1.77621 49.6 (L26)
22 30.825 11.00 1.49845 81.6 (L27)
23 −63.371 3.40 24 43.897 10.00 1.49845 81.6 (L28)
25 −399.180 (D25= Adjustable) 26 Infinity 35.50 1.51872 64.1 27 Infinity 23.00 1.84668 24.0 28 Infinity 2.50 29 Infinity 2.70 1.51872 64.1 30 Infinity (Aspheric Surface Multiplier)
1 page kappa=1.0000C4=2.7143x10−6C6=−7.4345x10−10C 8= 2.0710x10−13 (spacing at the time of variable power)
Reference value Projection scale factor 73.36 71.99 70.67 d2 5.00 5.00 5.00 d9 7.87 6.00 4.21 d25 8.38 9.00 9.62 (spacing at the time of focusing) Reference value Projection scale factor 48.48 71.99 94.16 d2 5.70 5.00 4.80 d9 5.60 6.00 6.80 d25 9.229.00 8.69 (value corresponding to conditional expression)
(1) Bf/f=4.39(2) D12/f=3.46(3) |f1/f|=2.07[0042] Drawing 8 − drawing 12 are many aberration Figs. of the 2nd example. namely, many one [71.99 times the projection scale factor of this] o'clock aberration Figs. whose drawing 8 is the projection scale factors of criteria — drawing 9 — many one [48.48 times the projection scale factor of this] o'clock aberration Figs. — in drawing 10 , drawing 11 shows many one [73.36 times the projection scale factor of this] o'clock aberration Figs., and drawing 12 shows many one [70.67 times the projection scale factor of this] o'clock aberration Figs. for many one [94.16 times the projection scale factor of this] o'clock aberration Figs., respectively. Also in the 2nd example, it turns out like the 1st example that many aberration is amended good in the condition of a reference value, the condition which performed variable power, and the condition of having performed focusing so that clearly from each aberration Fig.
[0043] The [3rd example] Drawing 13 is drawing showing the lens configuration of the projection lens system concerning the 3rd example of this invention. In the projection lens system of the 3rd example the 1st lens group G1 The negative meniscus lens L11 which turned the aspheric surface-like convex to the screen side sequentially from the screen side, The biconcave lens L12 which turned the concave surface of weak curvature to the screen side, and the negative meniscus lens L13 which turned the convex to the screen side, It consists of cemented lenses (L14, L15) which consist of lamination of the biconcave lens L14 which turned the concave surface of weak curvature to the screen side, and the biconvex lens L15 to which the convex of curvature strong against a screen side was turned.
[0044] The cemented lens which consists of lamination of the biconvex lens L21 with which the 2nd lens group G2 turned the convex of weak curvature to the screen side sequentially from the screen side, and the negative meniscus lens L22 which turned the concave surface to the screen side (L21, L22), The cemented lens which consists of lamination of aperture-diaphragm AS, the biconcave lens L23 which turned the concave surface of weak curvature to the screen side, and the positive meniscus lens L24 which turned the convex to the screen side (L23, L24), The cemented lens which consists of lamination of the negative meniscus lens L25 which turned the convex to the screen side, and the biconvex lens L26 to which the convex of curvature strong against a screen side was turned (L25, L26), The cemented lens which consists of lamination of the biconcave lens L27 which turned the concave surface of weak curvature to the screen side, and the biconvex lens L28 to which the convex of curvature strong against

a screen side was turned (L27, L28), It consists of a biconvex lens L29 to which the convex of curvature strong against a screen side was turned, and a negative meniscus lens L210 which turned the concave surface to the screen side.
[0045] In addition, unlike the 1st example and the 2nd example, in the 3rd example, the optical-path modification means is not arranged in the optical path between the 1st lens group G1 and the 2nd lens group G2. However, two or more prism as color composition optical system is arranged like the 1st example and the 2nd example at the contraction side of the 2nd lens group G2, i.e., the inside of the optical path between the 2nd lens group G2 and a space light modulation element. Furthermore, while moving the whole lens system in accordance with an optical axis unlike the 1st example and the 2nd example, air spacing (d2) of the 1st lens L11 of the 1st lens group G1 and the 2nd lens L12 is changed, and focusing is performed. Moreover, variable power is performed like the 1st example and the 2nd example by changing air spacing (d9) of the 1st lens group G1 and the 2nd lens group G2, moving the whole lens system to a screen side. The value of the item of the projection lens system concerning the 3rd example of this invention is hung up over the next table (3).
[0046]
[Table 3]
(Whole item)
f=12.37FNO=3.24omega=40.44Bf=52.27 (lens item)
Field number r d n nu 1* 435.529 6.00 1.49290 57.1 (L11)
2 55.697 (D2= Adjustable) 3 -1260.152 3.00 1.51872 64.1 (L12)
4 52.205 29.94 5 179.961 3.00 1.62287 60.2 (L13)
6 43.973 9.99 7 -108.989 2.00 1.69978 55.6 (L14)
8 75.159 8.00 1.72733 29.2 (L15)
9 -166.003 (D9= Adjustable) 10 73.795 5.00 1.59903 35.5 (L21)
11 -23.025 1.20 1.77621 49.6 (L22)
12 -77.804 2.90 13 Infinity 20.30 (Aperture-Diaphragm AS)
14 -152.862 2.00 1.80085 45.3 (L23)
15 37.482 4.50 1.48914 70.4 (L24)
16 90.114 4.00 17 49.649 2.00 1.77621 49.6 (L25)
18 41.021 8.00 1.49845 81.6 (L26)
19 -41.285 2.80 20 -389.673 2.00 1.80401 42.2 (L27)
21 34.438 9.00 1.49845 81.6 (L28)
22 -53.185 3.40 23 54.098 6.00 1.49845 81.6 (L29)
24 -97.648 2.30 25 -53.319 6.00 1.48914 70.4 (L210
26 -60.618 (D26= Adjustable) 27 Infinity 35.50 1.51872 64.1 28 Infinity 23.00 1.84668 24.0 29 Infinity 2.50 30 Infinity 2.70 1.51872 64.1 31 Infinity (Aspheric Surface Multiplier)
1 page kappa=1.0000C4=2.4042x10-6C6=-5.7580x10-10C 8= 1.8996x10-13 (spacing at the time of variable power)
Reference value Projection scale factor 73.37 72.05 70.77 d2 9.70 9.70 9.70 d9 52.37 50.00 47.72 d26 6.37 6.92 7.47 (spacing at the time of focusing) Reference value Projection scale factor 48.36 72.05 83.89 d2 10.50 9.70 9.50 d9 50.00 50.00 50.00 d26 7.006.92 6.90 (value corresponding to conditional expression)
(1) Bf/f=4.22(2) D12/f=4.04(3) |f1/f|=2.07[0047] Drawing 14 - drawing 18 are many aberration Figs. of the 3rd example. namely, many one [72.05 times the projection scale factor of this] o'clock aberration Figs. whose drawing 14 is the projection scale factors of criteria -- drawing 15 -- many one [48.36 times the projection scale factor of this] o'clock aberration Figs. -- in drawing 16 , drawing 17 shows many one [73.37 times the projection scale factor of this] o'clock aberration Figs., and drawing 18 shows many one [70.77 times the projection scale factor of this] o'clock aberration Figs. for many one [83.89 times the projection scale factor of this] o'clock aberration Figs., respectively. Also in the 3rd

example, it turns out like the 1st example and the 2nd example that many aberration is amended good in the condition of a reference value, the condition which performed variable power, and the condition of having performed focusing so that clearly from each aberration Fig.

[0048]

[Effect of the Invention] As explained above, in this invention, it is a wide angle, and projector distance is short, a back focus is long, and the projection lens system which has good tele cent rucksack nature can be realized. Especially, in the projection device using a liquid crystal panel, it can project by high contrast, and aberration, such as distortion aberration, including many is still smaller, and the projection lens system which can make an optical-path change inside can be realized. And when the projector lens equipped with the optical-path modification means of this invention, for example is applied to the projection device using a space light modulation element etc. and a projection display is constituted, while small equipment with so small depth etc. is obtained with a thin shape, good image quality will also be expected.

[0049] Moreover, a good display image is obtained by moving each lens group along the direction of an optical axis, and performing focus control (focusing). That is, without causing the phenomenon in which the image core on a screen shifts, like [at the time of adopting the so-called focusing of a whole delivery method], a focus control activity can be done easily, and even when the projection lens system of this invention is adopted as the projection display of different screen size, a good display image is obtained. Moreover, by moving each lens group along the direction of an optical axis, and being made to perform variable power, it becomes possible to absorb the effect of a projection lens system or the manufacture error of a projection display, and compaction of the cost reduction of a display and adjustment working hours is attained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the lens configuration of the projection lens system concerning the 1st example of this invention.

[Drawing 2] It is drawing showing many one [71.89 times the projection scale factor of this] o'clock aberration Figs. which are the projection scale factors of criteria in the 1st example.

[Drawing 3] It is drawing showing many one [48.17 times the projection scale factor of this] o'clock aberration Figs. in the 1st example.

[Drawing 4] It is drawing showing many one [83.75 times the projection scale factor of this] o'clock aberration Figs. in the 1st example.

[Drawing 5] It is drawing showing many one [73.21 times the projection scale factor of this] o'clock aberration Figs. in the 1st example.

[Drawing 6] It is drawing showing many one [70.57 times the projection scale factor of this] o'clock aberration Figs. in the 1st example.

[Drawing 7] It is drawing showing the lens configuration of the projection lens system concerning the 2nd example of this invention.
[Drawing 8] It is drawing showing many one [71.99 times the projection scale factor of this] o'clock aberration Figs..which are the projection scale factors of criteria in the 2nd example.
[Drawing 9] It is drawing showing many one [48.48 times the projection scale factor of this] o'clock aberration Figs. in the 2nd example.
[Drawing 10] It is drawing showing many one [94.16 times the projection scale factor of this] o'clock aberration Figs. in the 2nd example.
[Drawing 11] It is drawing showing many one [73.36 times the projection scale factor of this] o'clock aberration Figs. in the 2nd example.
[Drawing 12] It is drawing showing many one [70.67 times the projection scale factor of this] o'clock aberration Figs. in the 2nd example.
[Drawing 13] It is drawing showing the lens configuration of the projection lens system concerning the 3rd example of this invention.
[Drawing 14] It is drawing showing many one [72.05 times the projection scale factor of this] o'clock aberration Figs. which are the projection scale factors of criteria in the 3rd example.
[Drawing 15] It is drawing showing many one [48.36 times the projection scale factor of this] o'clock aberration Figs. in the 3rd example.
[Drawing 16] It is drawing showing many one [83.89 times the projection scale factor of this] o'clock aberration Figs. in the 3rd example.
[Drawing 17] It is drawing showing many one [73.37 times the projection scale factor of this] o'clock aberration Figs. in the 3rd example.
[Drawing 18] It is drawing showing many one [70.77 times the projection scale factor of this] o'clock aberration Figs. in the 3rd example.
[Description of Notations]
G1 The 1st lens group
G2 The 2nd lens group
M Mirror
P Prism
AS Aperture diaphragm
Li Each lens

[Translation done.]